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Original Article

Characterization of hip and knee arthroplasties and factors associated with infection☆

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ABSTRACT

Objective: To characterize arthroplasty procedures, calculate the surgical infection rate and identify related risk factors.

Methods: This was a retrospective cohort study. Data on operations performed between 2010 and 2012 were gathered from documental sources and were analyzed with the aid of statistical software, using Fisher's exact test, Student's *t* test and the nonparametric Mann–Whitney and Wilcoxon tests.

Results: 421 total arthroplasty procedures performed on 346 patients were analyzed, of which 208 were on the knee and 213 on the hip. It was found that 18 patients (4.3%) were infected. Among these, 15 (83.33%) were reoperated and 2 (15.74%) died. The prevalence of infection in primary total hip arthroplasty procedures was 3%; in primary total knee arthroplasty, 6.14%; and in revision of total knee arthroplasty, 3.45%. *Staphylococcus aureus* was prevalent. The length of the surgical procedure showed a tendency toward being a risk factor ($p = 0.067$).

Conclusion: The prevalence of infection in cases of primary total knee arthroplasty was greater than in other cases. No statistically significant risk factors for infection were identified.

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Caracterização de artroplastias de quadril e joelho e fatores associados à infecção

Palavras-chave:
Segurança do paciente
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Artroplastia
Cuidados intraoperatórios
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RESUMO

Objetivo: Caracterizar as artroplastias, calcular a taxa de infecção cirúrgica e identificar fatores de risco relacionados.
Métodos: Estudo de coorte retrospectivo. Os dados das cirurgias feitas entre 2010 e 2012 foram coletados em fontes documentais e analisados com auxílio de programa estatístico e testes exato de Fisher, *t* de Student e não paramétrico de Mann–Whitney e Wilcoxon.
Resultados: Foram analisadas 421 artroplastias totais em 346 pacientes, 208 de joelho e 213 de quadril; 18 (4,3%) pacientes infectaram; entre esses, 15(83,33%) foram reoperados e dois (15,74%) evoluíram para óbito. A prevalência de infecção em artroplastia total de quadril primária foi de 3%, em artroplastia total de joelho primária de 6,14% e em revisão de artroplastia total de joelho de 3,45%; *Staphylococcus aureus* foi prevalente. O tempo de duração da cirurgia indicou uma tendência como fator de risco ($p = 0,067$).
Conclusão: A prevalência de infecção em artroplastia total de joelho primária foi superior às demais e não foram identificados fatores de risco para infecção com significância estatística.

Introduction

Of the 234 million surgeries performed in the world in 2004, the equivalent of one operation for every 25 people, two million resulted in death in the perioperative period and approximately seven million had complications, of which 50% were considered preventable.

Considering the magnitude of the problem, in 2009 the World Health Organization (WHO) established 10 objectives aiming to ensure and promote the surgical patient's safety; the sixth objective recommends that the health team use known methods to minimize the risk of surgical infection and the tenth deliberates that hospitals and public health systems must establish surveillance on the surgical capacity, volume and results.[1] Thus, it is considered that epidemiological studies can contribute to the planning of prevention measures for surgical infections and improve the provided quality of care.

The surgical site infection (SSI) is one of the most severe complications and defined as one that manifests within 30 days after the surgical procedure. In surgical procedures that include implant or prosthesis, a period of up to one year after surgery is considered as a diagnostic criterion.[2]

For the Center for Diseases Control and Prevention, in the United States of America, SSI is responsible for approximately 17% of all healthcare-associated infections (HAI)[3]; in Brazil, it is the third most frequent infection, affecting between 14% to 16% of hospitalized patients[4] and for the WHO, this complaint represents 37% of all infections.[1] The SSI can be classified as superficial or deep; those considered superficial are the ones involving only the skin and the subcutaneous layer, whereas those involving deep incision tissue, such as fascia and muscles, are considered deep.[4]

Among the orthopedic surgical procedures that include prostheses, the total hip arthroplasty (THA) and total knee arthroplasty (TKA) are performed for the treatment of chronic refractory pain, mostly caused by osteoarthritis, lesions caused by rheumatoid arthritis, avascular necrosis and fractures.[5] The arthroplasty provides better quality of life; however, among the possible complications the occurrence of postoperative infection stands out.[6,7] This is considered a severe complication due to the morbidity associated with prolonged hospitalization and need for surgical reinterventions and may result in shortening of the affected limb, severe deformities and death.[7]

The National Health Surveillance Agency of Brazil recognizes the importance of preventive actions and experimentally launched in 2014 the National Arthroplasty Register program. This initiative will allow the surveillance of implants and based on the database and epidemiological studies, the establishment of actions to reduce risks, assess the quality of implants, as well as prevent postoperative complications, which will contribute to the safety of surgical patients.[8]

A rapid clinical and laboratory diagnosis of SSI in joint prostheses may increase the chances of solving the problem, as they are severe and high-cost events[9] and the knowledge of these complications' epidemiology will contribute to their prevention. Epidemiological surveillance, reporting of infection cases and information feedback to the surgical team are also strategies in the prevention of these diseases, in addition to stimulating the multidisciplinary team's commitment.[10]

In this sense, the epidemiology of cases of arthroplasties that have developed infection contributes to promote corrective and preventive actions, as well as promote the safety of the surgical patient. Therefore, the aims of this study were to characterize arthroplasties, calculate the surgical infection rate and identify associated risk factors.

Method

This is a retrospective cohort study, which used prospectively collected data, approved by the Research Ethics Committee under registration number 1102.027.11.04/CAAE

0026.0.091.208-11, carried out in a teaching hospital in Curitiba, state capital of Parana, Brazil.

The study period comprised 36 months (January 2010 to December 2012) and included all surgical procedures for hip or knee replacements. From the database related to study period surgeries, physical and electronic medical records and infection notification forms generated by the Hospital Infection Control Service were assessed. Notification of hospital infections resulted from prospective epidemiological surveillance during hospitalization and outpatient return, in the period up to one year after surgery; the criteria, diagnosis and classification of infection used in the study were those recommended by the Centers for Disease Control and Prevention[11] and the National Health Surveillance Agency of the Brazilian Ministry of Health.[2,4]

Based on documental sources, the following data were collected and entered into a Microsoft Excel 2007 spreadsheet: patient's register and name, age, gender, medical diagnosis that motivated the surgery, date of hospital admission and discharge (discharge or death), type of arthroplasty surgery (primary or secondary), site of the procedure (THA or TKA), unilateral or simultaneous bilateral procedure, time of the start and end of surgery and patient outcomes. Of patients who developed SSI, information was also collected about performed cultures and isolated microorganisms, characterization of infection (superficial, deep, of organ or space), readmission, reoperation and clinical outcome.

Data were analyzed using the Statistical Package for Social Sciences v. 20.0 and the results obtained from quantitative variables were described as mean, standard deviation, minimum and maximum values. Qualitative variables were expressed as frequencies and percentages such as those related to gender, number of surgeries per patient, baseline medical diagnosis, description and type of surgery and evolution or not to infection. Fisher's exact test was used to assess the association between two dichotomous qualitative variables. The comparison of groups defined by infection (yes or no), in relation to age, was carried out using Student's *t* test for independent samples; and comparison between surgeries with and without infection, in relation to the time of surgical procedure was carried out using the nonparametric Mann–Whitney test. The nonparametric Wilcoxon test was used compare the preoperative time with the time of postoperative hospitalization among cases of surgeries that developed and did not develop infection. The *p*-values <0.05 were considered statistically significant.

Results

During the study period, 421 total arthroplasties were performed in 346 patients, of which 213 (50.59%) were THA and 208 (49.41%) TKA; 146 (42.2%) were performed in male patients and 200 (57.8%) in females. The patients' ages ranged from 13 to 92 years with a mean age of 59.17 (SD = 14.7); 276 (79.8%) were submitted to only one surgery, 65 (18.8%) to two surgeries and five (1.4%) to three arthroplasties.

All patients received 1 g of cefazolin in the first surgery, up to 30 min prior to surgical incision and this prophylactic antibiotic was maintained for up to 24 h after surgery, according to the institutional protocol for orthopedic surgery with prosthesis. In reoperations due to infection, treatment was specific for each case. Among the baseline diagnosis for surgical indication, there was a prevalence of coxarthrosis and gonarthrosis (Table 1).

Table 1 – Medical diagnosis of patients undergoing total hip and knee arthroplasty, 2010 to 2012.

Diagnosis	N	%
Primary coxarthrosis, bilateral	105	24.94
Primary gonarthrosis, bilateral	99	23.5
Primary gonarthrosis, unilateral	36	8.6
Other types of rheumatoid arthritis	27	6.4
Fixation device complication	25	5.93
Unspecified gonarthrosis	21	5.0
Primary coxarthrosis	19	4.5
Unspecified coxarthrosis	13	3.1
Rheumatoid Arthritis	9	2.13
Others	67	15.9
TOTAL	421	100

Table 2 – Infection rates in the performed primary and revision arthroplasty surgeries, 2010 to 2012.

Infection	Primary surgery, N (%)	Revision surgery, N (%)
No	361 (95.5)	42 (97.67)
Yes	17 (4.5)	1 (2.33)
Total	378	43

Regarding the type of surgery, 378 (89.8%) were primary (199 THA and 179 TKA) and 43 (10.2%) were revision surgeries. Of these, 14 were THA and 29 were TKA revisions (Table 2). The prevalence of SSI in primary THA was 3%, whereas in primary TKA it was 6.14%; in TKA revision, it was 3.45%. After applying Fisher's exact test, no significant difference was identified in the occurrence of infection among primary and revision surgeries ($p = 0.707$).

There were 18 cases of infection in 18 patients, which resulted in a prevalence rate of 4.3%; all patients were readmitted for treatment, 15 (83.33%) were reoperated and two (11.1%) died due to the infection. The prevalence rate of infection in THA was 2.8% (six cases) and in TKA was 5.78% (12 cases). Infections classified as organ/space (77.78%, $n = 14$) were the most prevalent, with five cases in THA and nine in TKA, followed by deep infections (22.22%, $n = 4$), one in THA and three in TKA.

The mean surgical time in patients that developed and did not develop infection is shown in Fig. 1. The null hypothesis that the surgical time was equal in both groups was tested, *versus* the optional hypothesis of different times, using Mann–Whitney test; the result indicated a trend that times were different ($p = 0.067$).

Of the 18 patients with infection, 14 were women in a population of 200 patients; and four were men in a population of 146 patients; after applying Fisher's exact test, it was concluded that there was no significant difference in the proportion of infections between women and men ($p = 0.134$). Regarding age, the mean among patients that developed infection was 55.4 years (SD = 17.5) and the mean among cases that did not develop infection was 59.4 years (SD = 14.6). The Student's *t*

Table 3 – Association between the pre- and postoperative periods and infection after performed total hip and knee arthroplasty surgeries, 2010 to 2012.

	Infection	N	Mean	Median	Minimum	Maximum	Standard deviation	*p*-Value
Preoperative hospital stay	No	403	1.25	1	0	27	1.94	0.258
	Yes	18	1.72	1	0	8	2.02	
Postoperative hospital stay	No	403	4.47	3	1	56	4.66	0.225
	Yes	18	8	3	2	63	14.02	

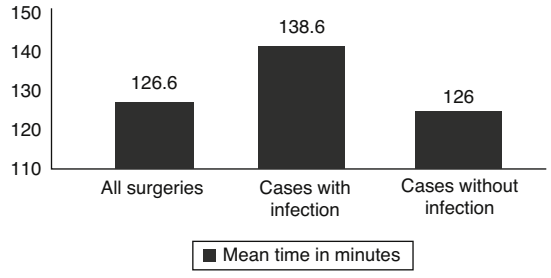

Fig. 1 – Time in minutes of performed hip and knee arthroplasty surgeries, 2010–2012.

test showed that the mean age was not different between the groups ($p = 0.265$).

Considering all surgeries ($n = 421$), the mean hospital length of stay was 5.9 days (SD = 6.2), with a minimum of two and maximum of 69 days; the mean hospital length of stay in readmission was 24.1 days, with a minimum of five and maximum of 57 days (SD 16.9). Regarding the pre- and postoperative hospital length of stay, we tested the null hypothesis of equal mean hospital length of stay between the group that developed infection and the group that did not develop infection, using the nonparametric test of Mann–Whitney. There was no significant difference in the preoperative time of hospitalization between groups ($p = 0.258$); or in the time of postoperative hospitalization ($p = 0.225$) as shown in Table 3.

Among the 18 cases of infection, 17 had material collected for culture; *Staphylococcus aureus* was the most commonly identified microorganism (Table 4).

Table 4 – Culture results among cases of infection of performed total hip and knee replacements, 2010 to 2012.

Results	N	%
Positive culture	14	82.4
Staphylococcus aureus	7	41.2
Klebsiella pneumoniae ESBL	2	11.8
Enterococcus faecalis	1	5.9
Enterococcus faecium and *Acinetobacter baumannii*	1	5.9
Escherichia coli	1	5.9
Streptococcus agalactiae	1	5.9
Coagulase-negative staphylococci and Citrobacter	1	5.9
Negative culture	3	17.6
Total	17	100.0

Discussion

The clinical and epidemiological profile of patients submitted to arthroplasty surgery during the study period is characterized by patients with predominant diagnoses of coxarthrosis and gonarthrosis, with a median of 59.17 years and undergoing primary surgery. There was a higher frequency of women undergoing surgery, which corroborates a review study on factors associated with knee osteoarthritis performed by Zhang and Jordan[12] in 2010, which indicated that females are most often affected by osteoarthritis after menopause due to hormonal changes; regarding the development of infection, there was no significant difference between men and women.

The mean age of patients submitted to THA and TKA reported by the researchers ranged from 63 to 75 years,[7,12,13] older than what was observed in this study, which was 59 years. The joint diseases that most often affect individuals submitted to THA and TKA are the osteoarthrites.[5,6,13] Piano, Golmia and Scheinberg carried out a study in Brazil and demonstrated that the diagnostic profile of patients reached 92.4% only for osteoarthritis and 2% for inflammatory arthritis.[14] In this study, although the diagnostic classification is more specific, in general the results are similar, but with a higher prevalence of arthritis.

Another study carried out in a Brazilian hospital by Lenza et al.[13] described the epidemiological characteristics and adverse events of patients submitted to THA and TKA; the prevalence of superficial SSI was 1.45% in THA and 1.2% of in TKA, which required antimicrobial treatment, but not reoperation. In similar studies, the SSI rate was 6.42% in 592 patients submitted to primary TKA[15] and in TKA revisions, it varied from 9%[16] to 25.2%.[17] In this study, the incidence of deep and organ/space infection in THA was 2.8% and 5.78% in TKA and all patients were submitted to antibiotic therapy and reoperation.

Deep infections result in adhesion, colonization, biofilm formation and bacterial adhesion to the implanted material, in addition to becoming a barrier that prevents antibiotic action; as the bacterial dissemination over the biomaterial makes the infection chronic and resistant, the choice of treatment is implant removal.[18] Whitside et al.[19] considered as the gold standard for the treatment of TKA infection, implant removal and new surgical intervention for revision in two stages, with the intravenous administration of antibiotics for six weeks and filling the joint cavity with antibiotic-loaded bone cement spacer.

There has been an increase in the occurrence of infections in joint prostheses, considered a matter of concern, not only

for its severity potential, obvious influence on patient morbidity and mortality, but also due to the high costs for patients and the healthcare system.[9,18] A retrospective study carried out in Brazil by Dal-Paz et al.[20] estimated an additional cost of US $ 91,843.75 for 34 patients undergoing TKA and that developed infection.

The multidisciplinary team can use data from evidence-based studies to improve the use of resources and prevent unnecessary costs[12]; among the actions to prevent these infections, reduce costs and improve the use of hospital resources, it is essential to have professionals with different backgrounds, including at the financial and human resource departments, to share information, evaluate routines and make changes when necessary.[13]

Considering all surgeries in this study, the mean hospital length of stay was 5.9 days (SD = 6.2), with a minimum of two and maximum of 69 days. The increase in the patient's hospital stay is a variable that is directly related to the occurrence of infection and the financial costs. Prolonged hospitalization periods and readmissions, increase hospital costs, in addition to triggering morbidities associated with hospitalization.

Ideally, the mean hospital length of stay should not exceed five days in order not to become a risk factor for the patient[21]; considering all analyzed surgeries, the mean length of stay exceeded the suggested time and was significantly higher among patients who developed infection, which may also incur in higher financial costs.

As for the duration of the procedure, Ercole et al.[22] showed that among the infection cases, 79.4% occurred in patients submitted to orthopedic surgery lasting more than 120 min. In this study the mean surgical time for patients that developed infection was 138.6 min and 126 in those who did not develop it. Although not statistically significant, the result indicates a trend that times are different ($p = 0.067$) and reinforces this factor as a risk for the development of SSI.

The predominance of *Staphylococcus aureus* in the cultures supports the literature data[10,23] and although most of the surgeries were primary ones, secondary surgeries showed no evidence of being associated with infection, as well as gender and age.

Conclusion

There was equivalence between THA and TKA, with a prevalence of bilateral coxarthrosis and gonarthrosis and primary arthroplasties. Infections in primary TKA were more prevalent and risk factors with statistical significance were not identified; surgical time showed a tendency toward being an associated risk factor. There was a predominance of *Staphylococcus aureus* as the etiological infectious agent, emphasizing the importance of surgical preparation, as well as the improvement of surgical time, as a preventive measure.

Conflicts of interest

The authors declare no conflicts of interest.

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